Comparative study on Distribution of Phytoplankton according to seasonal variation at Thannamunai area and Kalladi Bridge area of Batticaloa Lagoon

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Abstract- Phytoplankton fluctuation analyzed at two sampling regions namely Kalladi Bridge area (A) and Thannamunai area *(B)* according to seasonal variation in the year 2015. The main study focused on season rather that physio-chemical analysis. Samples were collected in dry (June) and rainy (November) seasons. The sampling region B is comparatively has low salinity due to the construction of two bridges (Koddaimunai Bridge & New Bridge) because the water flow is highly restricted. The sampling region A is brackish water. During study period sea water mixing doesn't take place in dry season. During dry season species diversity was high rather than rainy season and during dry season high density of Diatoms were estimated at the sampling region B and high density of Cyanobacteria were estimated at the sampling region A. During rainy season high density of Cyanobacteria and Chlorophycean members were estimated both in the sampling regions A and B.

Index Terms- Phytoplankton, physio-chemical, Diatoms, Cyanobacteria, Chlorophycean, brackish water, species diversity.

I. INTRODUCTION

1.1. Phytoplankton

Phytoplankton are the autotrophic component of the plankton community. An autotroph is an organism that produces complex organic compounds from simple inorganic molecules using energy from light or inorganic chemical reactions. The base of aquatic life is a large complex group of organisms known as **plankton**. Plankton are not defined by size nor **taxonomy** (i.e., biological classification), but rather because they are passively carried by water motion. Although some plankton can swim, their ability to is generally less than the strength of water movement. Most planktonic organisms are small (less than a 1 mm). Plankton includes a wide variety of organisms such as algae, bacteria, single-celled animals. Many marine organisms including barnacles, lobsters, crabs, starfish, etc. begin their life with a planktonic stage. Plankton can be broadly divided into **phytoplankton** (plants or **photosynthetic** organisms), **zooplankton** (animals), and **bacteria**. Phytoplanktons carry out photosynthesis and are the base of the food chain in the water bodies.

1.2. Phytoplankton as Bio-indicators

This study examines whether plankton of the Batticaloa Lagoon could be considered as a bio-indicator of areas subjected to various anthropogenic influences. This study was a one year hydrochemical and biological survey in two areas of the Batticaloa Lagoon, each with different environmental conditions due to pollution from urban, industrial, thermal and agricultural wastes. Phytoplankton associations did not show any promising species. In the different lagoon areas, this community was differentiated into its major groups. In contrast, the *Microcystis, Anabaena* (Cyanobacteria) could be considered as a target species in highly eutrophic areas.

1.3. Importance of Phytoplankton

Phytoplankton obtain energy through a process called photosynthesis and must therefore live in the well-lit surface layer (termed the euphotic zone) of an ocean, sea, lake, or other body of water. Through photosynthesis, phytoplankton are responsible for much of the oxygen present in the Earth's atmosphere – half of the total amount produced by all plant life. Their cumulative energy fixation in carbon compounds (primary production) is the basis for the vast majority of oceanic and also many freshwater food webs (chemosynthesis is a notable exception). As a side note, one of the more remarkable food chains in the ocean – remarkable because of the small number of links – is that of phytoplankton fed on by krill (a type of shrimp) fed on by whales. In terms of numbers, the most important groups of phytoplankton include the diatoms, cyanobacteria and dinoflagellates, although many other groups of algae are represented. One group, the coccolithophorids, is responsible (in part) for the release of significant amounts of dimethyl sulfide (DMS) into the atmosphere. DMS is converted to sulfate and these sulfate molecules act as cloud condensation nuclei, increasing general cloud cover. Phytoplankton serve as the base of the aquatic food web, providing an essential ecological function for all aquatic life.

1.4. Eutrophication

The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing

organisms deplete the water of available oxygen, causing the death of other organisms, such as fish. Eutrophication is a natural, slow-aging process for a water body, but human activity greatly speeds up the process – (Art, 1993). . It may occur naturally but can also be the result of human activity (cultural eutrophication from fertilizer runoff and sewage discharge) and is particularly evident in slow-moving rivers and shallow lakes … Increased sediment deposition can eventually raise the level of the lake or river bed, allowing land plants to colonize the edges, and eventually converting the area to dry land." – (Lawrence and Jackson, 1998).

1.5. Batticaloa Lagoon

Batticaloa Lagoon is a very large estuarine lagoon in Batticaloa District, eastern Sri Lanka. The city of Batticaloa is located on land between the lagoon and the Indian Ocean.Batticaloa district is flourished with three lagoons, such Batticaloa lagoon, Valaichchenai Lagoon and Vakari Lagoon. Among them, Batticaloa lagoon is the largest lagoon in Batticaloa District. Batticaloa lagoon is a long and narrow lagoon situated in the east coast of Sri Lanka with the total area of approximately 11,500 ha of water. The lagoon is 56 km long. This lagoon extends from Eravur (Batticaloa district) in the north to Kalmunai (Ampara district) in the south. This lagoon opens in to the sea at two points. One in the southern end of the lagoon at Kallar and the other is midway of the lagoon at Palameenmadu which is close to the Batticaloa town. The Sampling region A (Seelamunai) is close to Palameenmadu.

II. Objective

Many studies indicated that phytoplankton population in water bodies oscillate quantitatively as well as qualitatively depending on the quality of waters they receive through the surface runoff. Therefore, depending on the water quality changes, their use as indicator organisms has become very important. Though the phytoplankton fluctuation influenced by the physio-chemical parameters, but this study totally focused on how the phytoplankton fluctuation influenced by seasonal variation.

Batticaloa lagoon receives waters from eight rivers in its catchments. The water quality of the lagoon gets deteriorated due to the activities of the surface runoff and catchments. The Physical & chemical properties of the lagoon water during monsoon rains & dry seasons were estimated and how the phytoplankton act as bio-indicator at Thannamunai (B) and Kalladi Bridge area (A) due to the seasonal and water quality variation.

The objective of the present study was to determine;

1. To determine the phytoplankton composition, species diversity & the density of different phytoplankton species of the Batticaloa lagoon in different seasons at Thannamunai (B) and Kalladi Bridge area (A).
2. To determine the condition of the lagoon water if algal blooms recorded at Thannamunai (B) and Kalladi Bridge area (A).
3. To determine the possibility of using species diversity & density of phytoplankton in the lagoon and diversity indices for the prediction of water quality using phytoplankton as environmental indicators.

III. Geography of Batticaloa

Batticaloa is in the eastern coast of Sri Lanka on a flat coastal plain boarded by the Indian Ocean in the east occupies the central part of the eastern Sri Lanka. Its average elevation is around 5 meters. Scenic beauty of the Batticaloa is the Lagoons. Batticaloa district has three lagoons such as Batticaloa Lagoon, Valaichchenai Lagoon, and Vakari (Panichchankerni) Lagoon. Among these lagoons, Batticaloa Lagoon is the largest lagoon and has 56 km long 162 square km area, extending from Pankudaweli in North and Kalmunai in South.

There are several islands within the Batticaloa Lagoon such as Puliayantheevu, Buffaloa Island, Bone Island Many bridges are built across the lagoon connecting the landmasses and the islands. The Puliayantheevu is the metropolitan place of the city. The biggest bridge of all is Lady Manning Bridge located at Kallady, which is the main access path to the city from the southern places of the district. This bridge is also famous for singing fishes which was considered musical sounds heard in the Kallady lagoon in the full moon day. A priest named Father Lang recorded this musical charm and broadcast it in the 1960s over the (Sri Lanka Broadcasting Cooperation) Batticaloa beaches are sandy and located along 4 km shoreline in the city and further extend through the neighboring places. They include Kallady beach, Pasikkudah and Kalkudah. Pasikkudah is a bay protected from the ocean, with a flat and sandy bed extending 150 to 200 meters from the shore.

3.1.Climate

Batticaloa has a tropical wet and dry climate under the Köppen climate classification, also generically referred to as 'dry-monsoonal climate'. Batticaloa's climate is temperate or moderate throughout the year. From March to May, the warmest time of the year, the maximum temperature averages around 32 degrees Celsius (88 degrees Fahrenheit). During the monsoon season from November to February heavy rains are recorded, with average temperature of 27°C. Average annual rainfall in Batticaloa is 1650 mm or 165 cm (65.00 in).

IV. METHODOLOGY

4.1. Study area and Sampling regions

The studied area is the Batticaloa lagoon. It was categorized into three basins, which are Northern basin, Southern basin and Intermediate basin. During 2015 investigation period June (dry season) and November (rainy season) water samples were collected from Intermediate basin (Kalladi Bridge area) this region is an estuary, to Northern basin (Thannamunai) at 2 regions. Water samples were collected at 10 m distance away from the shore by using a boat at the secchi disk level. So from each season two samples, totally 4 water samples were collected and analyzed. The algal members were identified at genus level.

The sampling region A (Kalladi Bridge area) was located at the Intermediate basin, sampling region B (Thannamunai) located at the Northern region. It was difficult to collect water samples in all the regions of Batticaloa lagoon due to time limitations. In this study the Batticaloa lagoon and its catchment was considered as an interacting ecosystem. Any activity within the catchment may influence the quality of water in its inlets thus causing changes in the phytoplankton assemblage of the lagoon. These changes could cause changes in the phytoplankton biomass within the lagoon. Therefore specifically two sampling regions were selected to represent seasonal variation of phytoplankton in the lagoon.

4.2. Collection of water samples, Sampling procedure and Estimation of Species

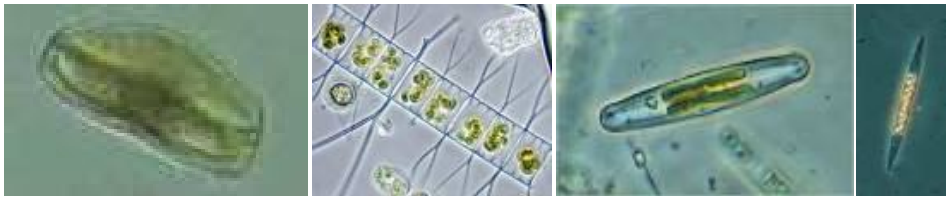
Sampling was done in June (dry season) and November (rainy season) at Kalladi Bridge area and Thannamunai respectively during the investigation periods 2015. At each sampling region secchi depths were determined using a black & white disc of 0.25 m in diameter, operated from the boat at 10 am. to 11.00 am. for comparative purposes. Then at each region, water samples were collected at secchi disc level 19 m away from the shore by using a Ruttner sampler with a volume of 2.5 L operated from the boat. The collected water samples were immediately transferred to sterile bottles and 100 ml of collected samples were again transferred to another sterile bottle then fixed with 1 ml Lugol's solution and covered with aluminium foil and placed in undisturbed box. The collected water samples were transferred to laboratory as quick as possible and maintained for 24 hrs under undisturbed condition. Then the sedimented phytoplankton mass were carefully separated by using a micro pipette and estimated the species composition by using haemocytometer.

V. RESULT AND DISCUSSION

Species indentified during the study period 2015 given below:

Division: Bascillariophyta (Diatoms):

Gyrosigma accuminatum *Nitzschia closterium* *Synedra fasciculate* *Navicula gibbula*

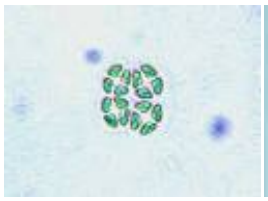


Eucocconeis flexella *Chaetoceros decipiens* *Navicula paludisa* *Nitzschia hungaria*

Cyclotella comta *Rhizosolenia alata* *Cyclotella stelligera* *Navicula radiosa*

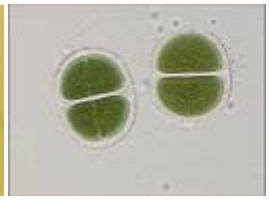

Cerataulina pelagic *Nitzschia amphibian*

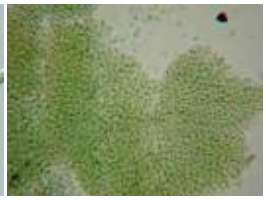
Division: Chlorophyta (Green algae):



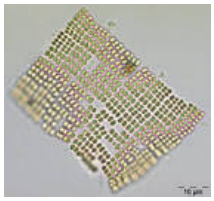
Tetrastrum triangulare *Monoraphidium contortum* *Koliella longiseta*

Division: Cyanophyta (Cyanobacteria):



Microcystis incerta *Chroococcus turgidus* *Oscillatoria agardhii* *Microcystis aeruginosa*



Merismopedia tenuissima

Division: Euglenophyta (Euglenoids):




Euglena sanguine *Phacus pyrum* *Phacus macrostigma* *Trachelomonas*

Division: Dianoflagellates:


Peridinium polonicum *Properidinium stenii*

June 2015 (Dry season) – Kalladi Bridge area (A)

Number of Species – 14. In 1x10^{-4} ml water sample.

Microcystis incerta (Cy), Gyrosigma accuminatum (B), Nitzschia closterium (B), Synedra fasciculate (B), Navicula gibbula (B), Eucocconeis flexella (B), Properidinium stenii (Di), Chaetoceros decipiens (B), Navicula paludisa (B), Nitzschia hungaria (B), Cyclotella comta (B), Rhizosolenia alata (B), Cyclotella stelligera (B), Microcystis aeruginosa (Cy).

Number of Diatom Species (B) were 12, Number of Cyanobacteria (Cy) was 1 and Number of Dinoflagellates was 1.

June 2015 (Dry season) - Thannamunai (B)

Number of Species – 12. In 1x10^{-4} ml water sample.

Microcystis aeruginosa (Cy), Microcystis incerta (Cy), Tetrastrum triangulare (C), Chroococcus turgidus (Cy), Oscillatoria agardhii (Cy), Peridinium polonicum (Di), Merismopedia tenuissima (Cy), Euglena sanguine (Eu), Navicula radiosa (B), Phacus pyrum (Eu), Phacus macrostigma (Eu), Trachelomonas (Eu).

Number of Diatom Species (B) was 1, Number of Cyanobacteria Species (Cy) were 5, Number of Green Algae Species (C) was 1, Number of Euglenoids (Eu) were 4 and Number of Dianoflagelates (Di) was 1.

November 2015 (Rainy season) – Kalladi Bridge area (A)

Number of Species – 8. In 1x10^{-4} ml water sample.

Microcystis incerta (Cy), Monoraphidium contortum (C), Tetrastrum triangulare (C), Chroococcus turgidus (Cy), Cyclotella stelligera (B), Euglena sanguine (Eu), Cyclotella comta (B), Cerataulina pelagic (B).

Number of Diatom Species (B) were 3, Number of Cyanobacteria Species (Cy) were 2, Number of Green Algae Species (C) were 2, and Number of Euglenoids (Eu) was 1.

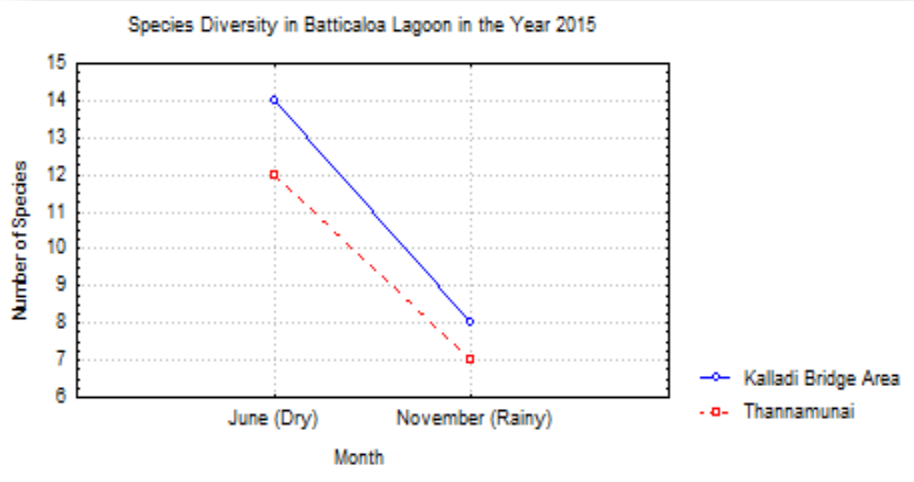
November 2015 (Rainy season) - Thannamunai (B)

Number of Species – 7. In 1x10^{-4} ml water sample.

Monoraphidium contortum (C), Chroococcus turgidus (Cy), Phacus macrostigma (Eu), Microcystis incerta (Cy), Nitzschia amphibian (B), Koliella longiseta (C), Tetrastrum triangulare (C).

Number of Diatom Species (B) was 1, Number of Cyanobacteria Species (Cy) were 2, Number of Green Algae Species (C) were 3, and Number of Euglenoids (Eu) was 1.

In the dry season the species diversity was high at the sampling regions Kalladi Bridge area (A) and Thannamunai (B) rather than rainy season. (Fig:1). Phytoplankton diversity and succession in the Iyagbe lagoon, **Lagos, Nigeria** was investigated for 24 consecutive months (Oct., 2004 - Sept., 2006). Phytoplankton diversity was clearly higher in the dry than wet season. (Onyema,I.C., 2010), Moreover Phytoplankton structure and diversity in the eutrophic-hypereutrophic reservoir Paso de las Piedras, Argentina were studied during January 2004 - June 2005. (Fernández, *et al.*, 2012). The result of this study also proved that the phytoplankton diversity was clearly higher in the dry than wet season. These investigations supporting the result.



At the sampling region A (Kalladi Bridge area) during dry season the salinity was high due to sea intrusion compare to the sampling region B (Thannamunai). Sampling region B (Thannamunai) is brackish water compare to the sampling region A (Kalladi Bridge area). During dry season density wise Bascillariophycean members (diatom) were high at the sampling region A (Kalladi Bridge area) and this estuarine water is moderately saline (Fig:2).

June 2015 – Kalladi Bridge area

Density of each species in 100ml sample;

(1). Microcystis incerta (Cy) – 100, (2). Gyrosigma accuminatum (B) – 100, (3). Nitzschia closterium (B) – 600, (4). Synedra fasciculate (B) – 200, (5). Navicula gibbula (B) – 100, (6). Eucocconeis flexella (B) – 100, (7). Properidinium stenii (B) – 100, (8). Chaetoceros decipiens (B) – 100, (9). Navicula paludisa (B) – 100, (10). Nitzschia hungaria (B) – 100, (11). Cyclotella comta (B) – 100, (12). Rhizosolenia alata (B) – 100, (13). Cyclotella stelligera (B) – 100, (14). Microcystis aeruginosa (Cy) – 200.

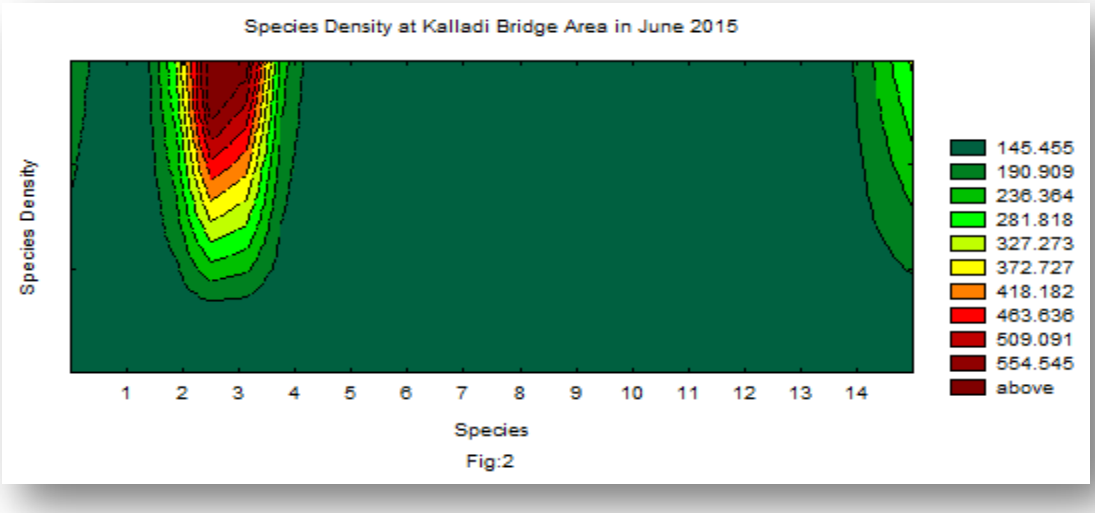


Fig:2

Salinity influences diatom physiology directly, by exerting an osmotic stress, but it may also affect species composition indirectly via interaction with other factors. For instance, both salinity and ion composition have an impact on nutrient dynamics in saline systems, specifically in terms of nutrient availability (Cole *et al*., 1986; Caraco *et al.*, 1989), requirements (Tuchman *et al*., 1984) and uptake rates (Bhattacharyya and Volcani, 1980; Mohleji and Verhoff, 1980); hence, nutrients may serve as a mechanistic link between diatom community structure and ionic concentration / composition. These factors may be the reason for high density of diatoms at the sampling region A (Kalladi Bridge area).

Cyanophycean members were high at the sampling region B (Thannamunai) (Fig:3). The sampling region B shows comparatively shallow and slow moving water condition and receiving surface runoff from paddy lands and small industries. Human activities (e.g., agricultural runoff, inadequate sewage treatment, runoff from roads) have led to excessive fertilization (eutrophication) of many water bodies. This has led to the excessive proliferation of algae and cyanobacteria in fresh water and thus has had a considerable impact upon recreational water quality. In temperate climates, cyanobacterial dominance is most pronounced during the summer months, though algal bloom was not been recorded during the study period. The majority of cyanobacteria are aerobic photoautotrophs. Their life processes require only water, carbon dioxide, inorganic substances and light. Photosynthesis is their principle mode of energy metabolism. In the natural environment, however, it is known that some species are able to survive long periods in complete darkness. Furthermore, certain cyanobacteria show a distinct ability for heterotrophic nutrition (Fay, 1965).

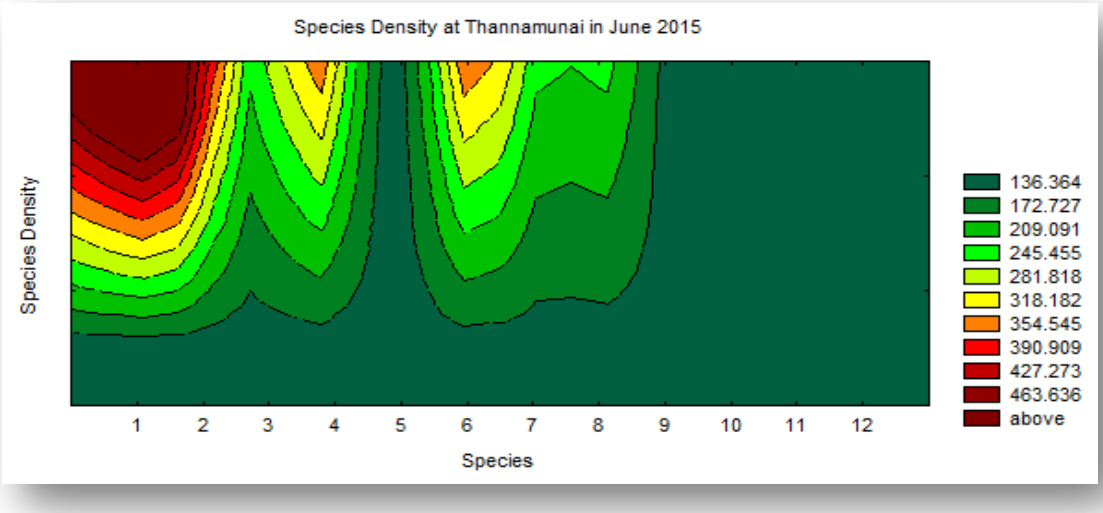
Microcystis aeruginosa

The nitrogen-fixing species contribute globally to soil and water fertility (Rai, 1990). The use of cyanobacteria in food production and in solar energy conversion holds promising potential for the future (Skulberg, 1995). However, cyanobacteria may also be a source of considerable nuisance in many situations. The high density cyanobacterial members indicating the mixing of harmful pollutants into the sampling region B (Fig:3).

June 2015 - Thannamunai

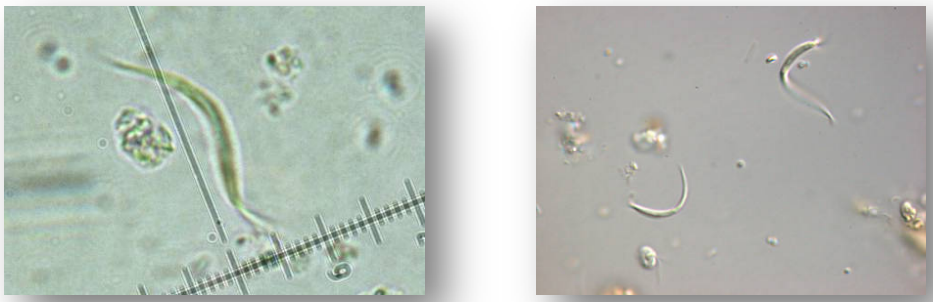
Density of each species in 100ml sample;

(1). Microcystis aeruginosa (Cy) – 500, (2). Microcystis incerta (Cy) – 500, (3). Tetrastrum triangulare (C) – 200, (4). Chroococcus turgidus (Cy) - 300, (5). Oscillatoria agardhii (Cy) – 100, (6). Peridinium polonicum (Di) – 300, (7). Merismopedia tenuissima (Cy) – 200, (8). Euglena sanguine (Eu) - 200 , (9). Navicula radiosa (B) – 100, (10). Phacus pyrum (Eu) – 100, (11). Phacus macrostigma (Eu) - 100 , (12). Trachelomonas (Eu) – 100.



During rainy season the Cyanophycean and Chlorophycean densities were high both in the sampling regions A (Kalladi Bridge area) (Fig:4) and B (Thannamunai) (Fig:5). The identification of the Cyanophycean members may be the reason of mixing the pollutants at both sampling regions A and B due to surface runoff during rainy season and the reason for high density of chlorophycean members is the green algae is the ancestors of higher plants and the sampling region B has shown suitable environment for the high density of Chlophycean members due to sufficient amount of nutrient, sunlight, temperature, and low salinity. The sampling regions A and B shows more or less same pattern of phytoplankton fluctuations (Fig:4) and (Fig:5). The identified high density Chlorophycean member was ***Monoraphidium contortum***.

Toxicity of cadmium, copper and zinc was tested on four green algal species (*Ankistrodesmus fusiformis*, *Chlorella ellipsoidea*, ***Monoraphidium contortum*** *and Scenedesmus acuminatus*) isolated from a **highly polluted river** (Matanza-Riachuelo River, Buenos Aires, Argentina). (amagda65@yahoo.com.ar).

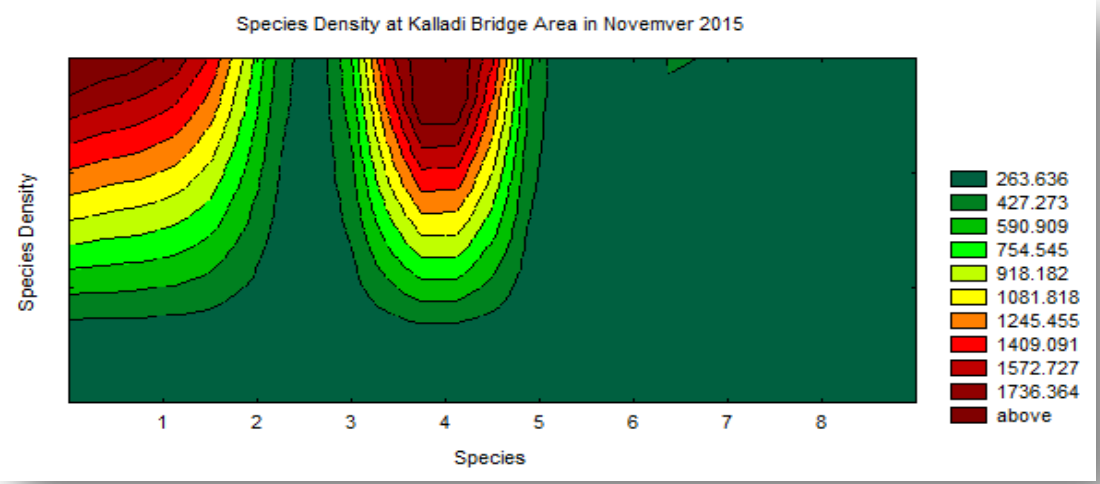


Monoraphidium contortum

November 2015 – Kalladi Bridge area

Density of each species in 100ml sample;

(1). Microcystis incerta (Cy) – 1500, (2). Monoraphidium contortum (C) – 1000, (3). Tetrastrum triangulare (C) – 200, (4). Chroococcus turgidus (Cy) – 1900, (5). Cyclotella stelligera (B) – 100, (6). Euglena sanguine (Eu) – 200, (7). Cyclotella comta (B) – 100, (8). Cerataulina pelagic (B) – 100.



November 2015 - Thannamunai

Density of each species in 100ml sample;

(1). Monoraphidium contortum (C) – 8900, (2). Chroococcus turgidus (Cy) – 5600, (3). Phacus macrostigma (Eu) – 300, (4). Microcystis incerta (Cy) – 3100, (5). Nitzschia amphibian (B) – 400, (6). Koliella longiseta (C) – 400, (7). Tetrastrum triangulare (C) – 3100.

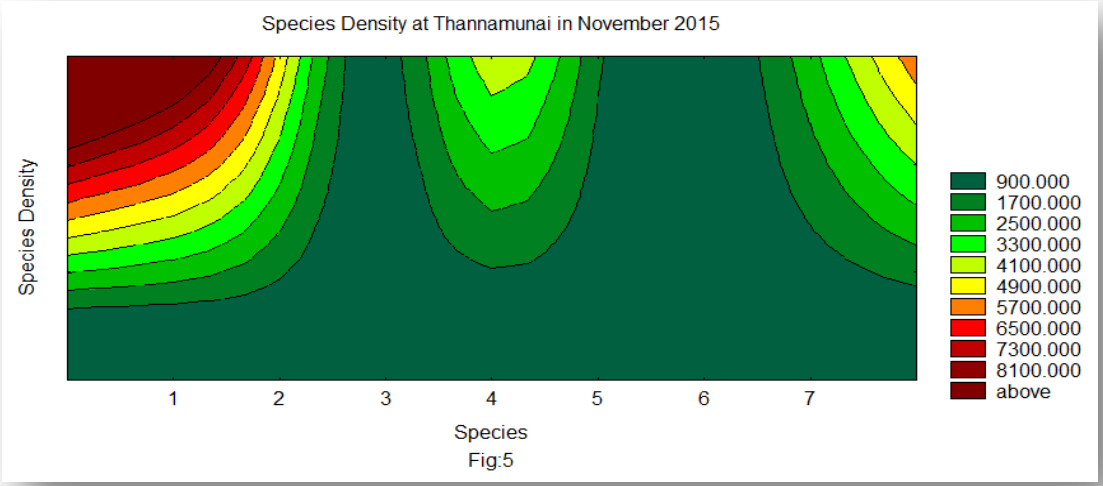


Fig:5

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